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Generating Continuous Surface Probability Maps from Airborne Video Using Two Sampling Intensities Along the Video Transect

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Generating Continuous Surface Probability Maps from Airborne Video Using Two Sampling Intensities Along the Video Transect

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Abstract

Airborne videography can be an effective tool for assessing the effects of catastrophic events on forest conditions. However, there is some question about the appropriate sampling intensity to use, especially when trying to develop correlations with probabilistic data sets such as are assembled through the Forest Inventory and Analysis (FIA) surveys. We used airborne videography to assess damage to forest resources by Hurricane Andrew and the catastrophic February 8-l 1, 1994, ice storm; but, those efforts were limited by the absence of a diit link between video imagery and FIA field plots. In this study, we used the 1994 ice storm in northern Mississippi to test bias and accuracy at two sampling intensities—14.5- by 14.5-km spacing (square) and a 14.5- by 1.6-km spacing (rectangular). Results showed that the square pattern resulted in less biased estimates of damage. We suggest that this bias would be lessened further if sampling was made on the 4.8-km sample grid of FIA data points. We assert that bias could be eliminated if imagery was acquired directly over FL4 plots.

Keywords: Airborne videography, digital-image files, FIA, global positioning system, ice storm, isozone.

Introduction

Both portable and easy to use, current airborne videography equipment is the ideal technology for quickly assessing damage to forest resources following catastrophic events. The U.S. Department of Agriculture, Forest Service, Southern Research Station, Forest Inventory and Analysis (SRS-FIA) research unit uses airborne videography and global positioning system (GPS) data to assess such damage. SRS-FIA also participates in cooperative research projects that effectively use airborne video reconnaissance.

Airborne videography has been used successfully to assess resource damage. Jacobs and Eggen-McIntosh (1993) reported consistent and repeatable methodologies, which had been developed following Hurricane Andrew's 1992 landfall in the Atchafalaya River Basin of southern Louisiana. The severe ice storm in northern Mississippi provided an opportunity to refine assessment procedures (Jacobs 2000), allowing us to increase consistency in visual analysis of video samples and automate the geographic information system (GIS) process used for mapping damage severity and extent. According to the 199 1 State inventory (Vissage and others 1992), the hurricane study area was 1.7 million ha and contained 729,000 ha of timberland. By comparison, the ice storm study area was 1.5 million ha and, according to 1994 inventory data (Faulkner and others 1993, Hartsell and London 1995), included 855,000 ha of timberland

For both studies, we captured digitally some selected video flames from continuous video recordings and visually interpreted damage severity. Damage classes and associated video-frame GPS coordinates were combined as point data for mapping damage-severity isolines. The GIS polygon coverage that resulted was used to extract field-plot information from associated FIA survey data. Plot data were compiled to generate a timber volume damage report by damage-class variable and species group for each study area.

Using airborne videography, we recorded a continuous transect of aerial imagery and acquired an almost unlimited density of sampling points along the flight line. However, cost vs. benefits played a major role in determining the number of flight lines, and the distance between flight lines for recording airborne videography limited both studies.

Our objective was to determine whether the bias in rectangular spacing of point data (14.5 by 1.6 km) could be overcome by reselecting data points along the flight lines equal to the distance between flight lines (14.5 by 14.5 km).

Materials and Methods

The airborne video system is used to acquire vertical aerial video imagery and identify images by geographic coordinates. The equipment is easily transportable and can be installed in an aircraft on the same day a video mission is flown. The system includes four main parts: (1) video camera head, (2) color video monitor, (3) GPS receiver, and (4) video recording unit containing a graphics computer. The video camera head contains a 2/3-inch format (16.93 mm), charge-coupled device (CCD) as the imaging plane (8.8 by 6.6 mm). An 1 1- to 66-mm zoom lens with auto-iris is attached to the camera head, and the camera head's overall weight is 1.25 kg. The video-recording unit includes an **8-mm** videocassette recorder and graphics computer, which can generate text onto the video imagery; e.g., GPS coordinates, altitude, and date and time. The recording unit also has a keyboard for entering text during the mission as well as power connections for all peripheral devices.

A flying altitude of 660 **m** and maximum zoom of 66 mm for the focal length of the camera lens provided a video-image footprint of 88 by 66 **m** (0.58 ha) for each sample location. Video flight lines were spaced at 14.5 km and oriented perpendicular (North/South) to the storm track We subsampled continuous vertical aerial video imagery **(frame** captured) along each flight line at **1.6-km** (1 mi) and **14.5-km** (9 mi) intervals for separate interpretation and analysis at both low- and high-sampling densities. We used GPS coordinates, encoded onto the video imagery in-flight, to name each **of the** frame-captured, digital-image files. File names were input as geographic coordinates, creating a GIS point coverage of the video sample point locations and associated damage-condition attributes. We chose sample point spacing for analysis at low (14.5 by 14.5 km) and high (14.5 by 1.6 km) densities to illustrate the difference between square-grid and rectangular-grid sampling and mapping functionality.

We interpreted video frames for hardwood and pine basal area and grouped our visual interpretations into one of four percent-hardwood categories. For each species group, we classified damage conditions separately; pines were more susceptible to stem damage from ice than hardwoods (Halverson and Guldin 1995). Ordinal damage severity classes included: 0 = none, 1 = light, 2 = moderate, and 3 = severe damage. We interpreted all video **frames** by **cross-**validation among flight lines and **frames** recording similar degrees of damage.

We chose Arc/Info's "SPLINE" function within the GRID program to calculate isolines **from** the point data. **Our** results were continuous surface probability maps showing **damage-**severity classes. We produced maps for low- (14.5 by 14.5 km) and high- (14.5 by 1.6 km) f&me-sampling densities.

Results

Figures 1 and 2 illustrate the continuous surface probability maps from the **"SPLINE"** function for the two sampling densities. An East/West measurement bias is obvious in

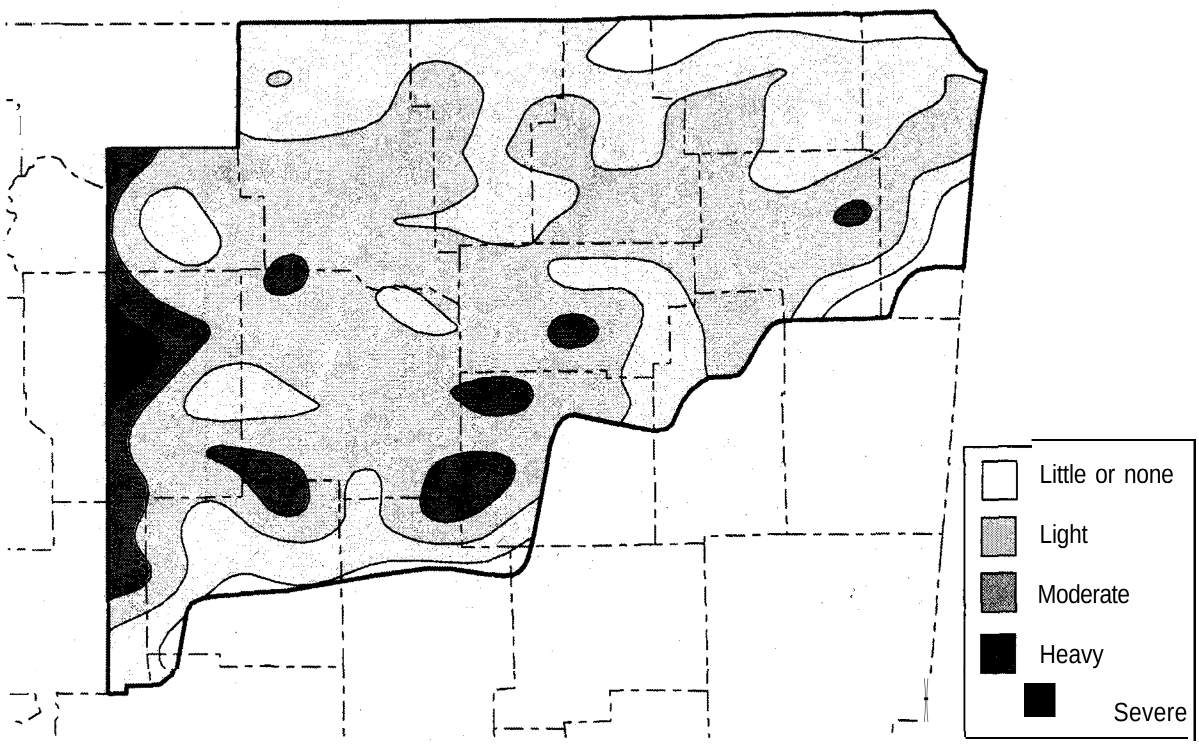

Figure l-Damage-severity isozones generated from high sample rate of 1.6 km by 14.5 km. An indicator of forest resources timber damage.

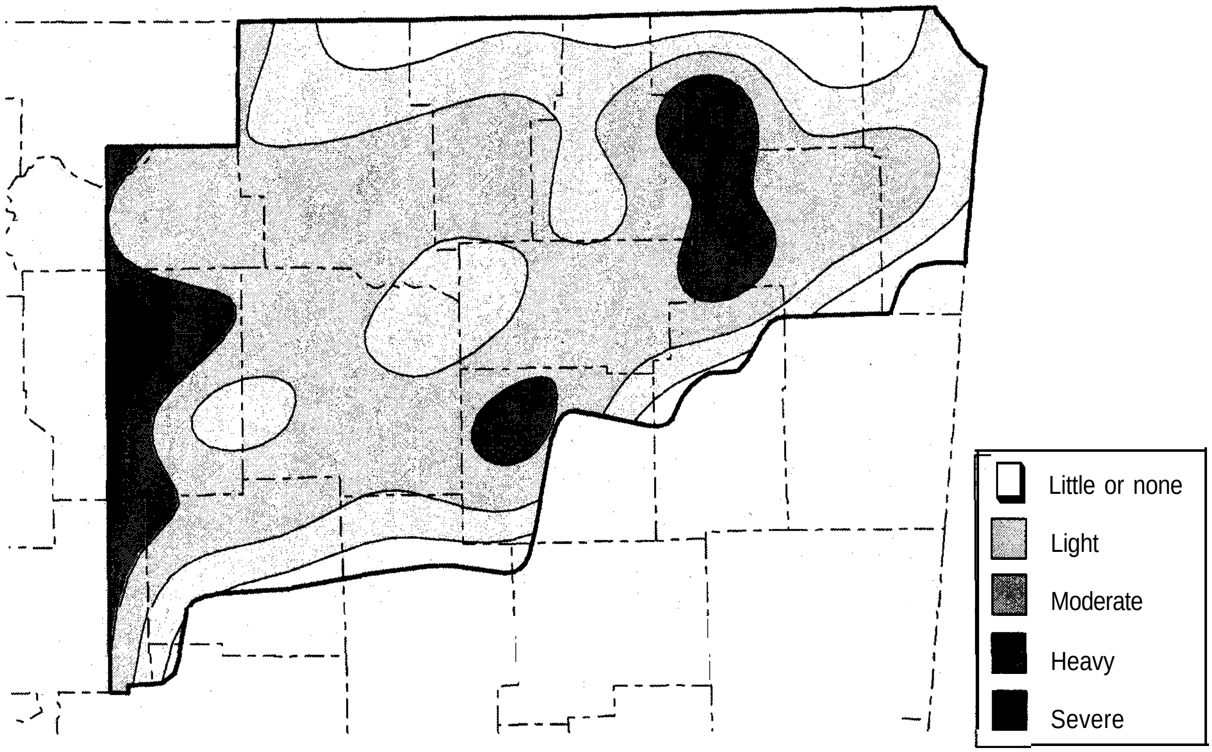

Figure 2-Damage-severity isozones generated from low sample rate of 14.5 km x 14.5 km.

figure 1. This bias is generated when the "SPLINE" function interpolates isolines within and around the data points spaced at 14.8- by 1.6-km density. When an isoline is placed around similarly valued data points on adjacent flight lines, it must be drawn over 14.8 km of open space before contouring between two data points spaced at 1.6 km along the flight line. An additional problem is gaps of no-data values along the flight line. Although continuous transects of video imagery were recorded, there were several places along the flight lines where no timberland was recorded for up to 13 km. A gap of this size would create a block of missing timberland data as large as 30 by 13 km.

Figures 3 and 4 illustrate FIA plot locations on surface probability maps. The low-damage isozones changed slightly in figure 4 because of the lower sampling intensity. The high-damage isozones had a greater change, both in size and in location, which resulted in plots receiving different damage assessment values.

Suggested preflight planning requirements of4.8 km (3 mi) flight-line centers necessary to coincide with FIA's systematic inventory grid would help eliminate this bias.

Administrative decisions and cost benefits concerning flight time for this study preempted the plan to space flight lines at 4.8 km. Efforts at estimating timber losses and damage affecting growth and mortality will help us describe our objectives for projects like these.

Discussion and Conclusions

Automated isoline calculation programs are included with most GIS software and provide a major improvement over hand drawing of damage-severity polygons. Such programs reduce analyst subjectivity and improve repeatability of results.

The greater sampling density of rectangular-spaced sample points creates a visual bias because there are more samples North/South than East/West. The low-sample density of regularly spaced sample points removes the effect of East/West bias, but it does so at the expense of reduced interpolation precision. Conclusions from this study strongly suggest that 4.8-km flight-line centers will be necessary to synchronize this type of analysis with the 4.8

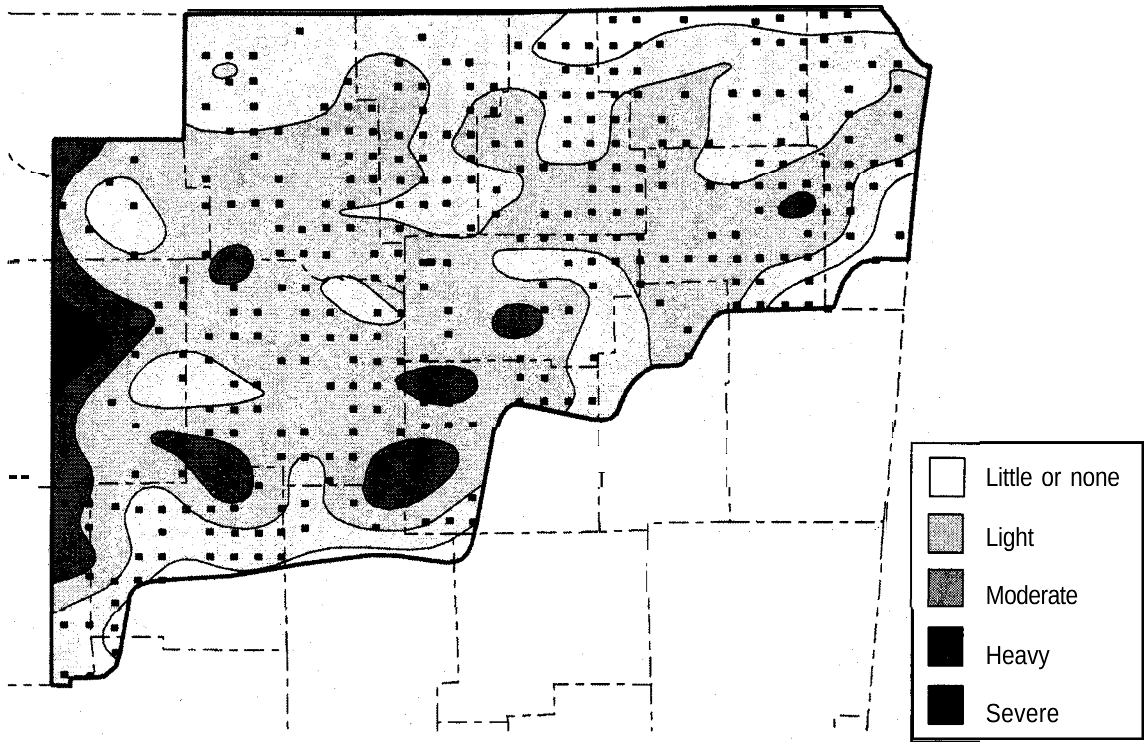

Figure 3-Damage-severity isozones generated from high sample rate of 1.6 km x 14.5 km. **FIA** plot locations shown within the damage zones.

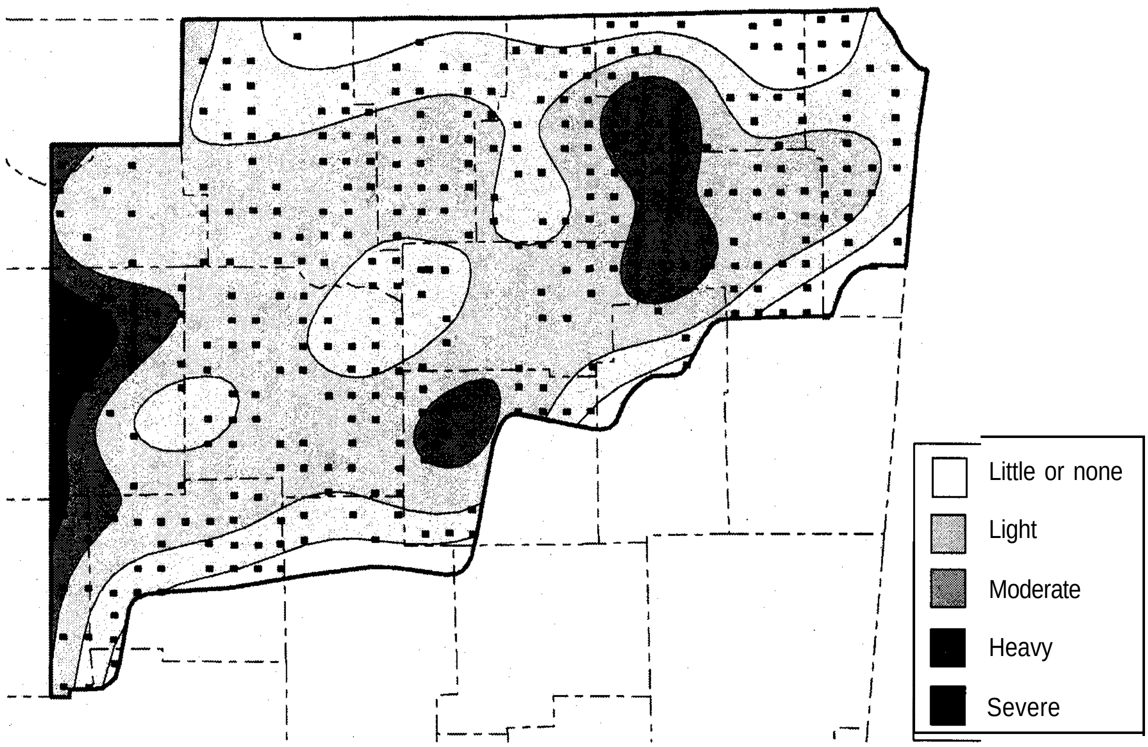

Figure 4-Damage-severity isozones generated from low sample rate of 14.5 km x 14.5 km. **FIA** plot locations shown within the damage zones.

by 4.8 km systematic spacing of FIA plot data. Lack of field verification of damage-severity classes was a problem in this study. To ensure optimum field verification, future studies would also benefit from aerial imagery captured directly over FIA plots.

The airborne video system developed and used by SRS-FIA has been a valuable tool when rapid responses to natural catastrophic events were necessary. The combination of wind and ice damage (ice storm), or wind damage alone (hurricanes) can be characterized spatially through interpretation of aerial video. GPS coordinates encoded onto the video facilitate development of a GIS for an affected area. GIS data, coupled with current databases of forest resources, enable analysts to develop estimates of damage soon after the storm event.

Airborne video is increasingly used as a monitoring tool. SRS-FIA has been involved in cooperative projects using GPS and airborne video to provide vegetative ancillary information for satellite imagery classifications in Mexico and for mapping and monitoring natural resource changes in western Africa (Wood and others 1995). Cooperative efforts of SRS-FIA and the Indonesian Ministry of Forestry, as well as the Wagenengin Agricultural University in The Netherlands, use frame-captured aerial videography to facilitate interpretation of airborne radar imagery over the Jambi province of Sumatra, Indonesia. We have scheduled hands-on interpretation of radar imagery and aerial videography for future projects. This is an exciting opportunity for technology transfer between countries interested in monitoring the condition of forest resources worldwide.

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